Cr^{2+}:CdSe – A Breakthrough Mid-Infrared Laser Material

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Payoff

Using Small Business Innovation Research (SBIR) program funds, the Sensors Directorate (SN) and Cleveland Crystals, Inc. achieved breakthroughs in both the preparation and the lasing of Cr^{2+}:CdSe crystals. These crystals have been demonstrated to be a viable source of high power, tunable radiation in the 2.3 – 2.9 micron range. With further development, these crystals will be candidates for use in military infrared countermeasure platforms and for commercial use in the detection of biological and chemical agents or environmental sensing.

Accomplishment

Using SBIR funding, the Air Force Research Laboratory's (AFRL's) Sensors Directorate contracted with Cleveland Crystals, Inc. of Cleveland, OH, to develop an innovative technique to produce large, laser quality crystals of chromium-doped cadmium selenide, a novel mid-infrared laser material. In cooperation with Cleveland Crystals, SN has demonstrated the first lasing of this material with record-breaking efficiency and output power in the mid-infrared at room temperature.

Background

Compact, tunable, room temperature, solid-state laser sources operating in the mid-infrared (2-5 microns) spectral region are of interest for a number of applications, such as eyesafe laser radar, remote sensing, and infrared countermeasures. Traditionally, this spectral region has been difficult to obtain in laser sources, particularly in the solid-state arena. Solid-state sources are preferable because they tend to be more compact, reliable, and robust compared to other methods. Solid-state mid-infrared sources have been demonstrated through optical frequency conversion of 1-micron lasers to obtain wavelengths in the 2 – 5 micron region, and with semiconductor lasers that operate directly in this wavelength region, but success has been limited. These techniques tend to result in low efficiency and/or low output power devices. An additional challenge is that the longer the wavelength, the less likely it will work at room temperature. By contrast, the lasing source used in this program operates directly in the mid-infrared region at room temperature successfully. Cleveland Crystals grew pure cadmium selenide crystals and diffused them with Cr^{2+} ions. Their innovative method produced a crystal that has broadband absorption near 1.9 micron wavelengths and broadband emission over the 2-3 micron range. Once this was successfully accomplished, SN demonstrated a 2-micron pumped chromium laser with an average power of 500 mW at 2.6 microns with 48% conversion efficiency of absorbed power and achieved up to 815 mW at a reduced efficiency of 27% . The beam quality in both the horizontal and vertical directions was good, with divergence in both directions about two times the diffraction limit. These results will be scaled up for use in infrared countermeasures, which requires several watts of power at that wavelength. Additionally, broadband tuning over the 2.3-2.9 micron region was demonstrated, which makes this laser material of interest for use in commercial and military environmental sensing. Typically, the lasing source would be used to send out a pulse. The return from the wavelength sent out would then be analyzed to determine which components exist in the target environment. For instance it may detect ammonia, indicating a gas leak in an industrial chemical process. Cleveland Crystals will continue to provide Cr^{2+}:CdSe crystals to SN to continue this research.